THE SIDEREAL MESSENGER.

CONDUCTED BY WM. W. PAYNE,

DIRECTOR OF CARLETON COLLEGE OBSERVATORY.

NOVEMBER, 1888.

Thou Lord in the beginning hast laid the foundation of the earth and the heauens are the works of thy hands.

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THE SIDEREAL MESSENGER,

CONDUCTED BY WM. W. PAYNE,

DIRECTOR OF CARLETON COLLEGE OBSERVATORY, NORTHFIELD, MINN.

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THE EFFECTS OF ROTATION UPON THE FLUID ENVELOPE OF A REVOLVING SPHERE.

SEVERINUS J. CORRIGAN.

FOR THE MESSENGER.

If any one should enunciate the proposition that sun-spots and their periodicity, terrestrial storms (the word storm being, in this connection, taken as signifying a rotary motion of the earth's atmosphere, around what is called the storm centre), the oceanic circulation, and the seismic phenomena, are due primarily to one and the same cause, and that this cause is determinable, the bare announcement would undoubtedly be considered as rash in the superlative degree. To entitle such a proposition to even the slightest consideration by the scientific world, it is absolutely necessary that it should be amenable to a rigorous mathematical demonstration or proof, and furthermore, that this proof should be well buttressed by facts derived solely from observation; for, as is well known, the concordance of theory and observation is the life and soul of modern science; without such concordance theory must ever remain a barren ideal, at least so far as the practical advancement of science is concerned. With a thorough understanding and appreciation of the requirements aforesaid, I think that I am warranted in making the statement or proposition above mentioned. The hypotheses, the truth of which I hope to demonstrate, may be stated explicitly as follows: I hold that, on any spherical or spheroidal body, such as the sun or the earth, rotating around an axis and whose mass exerts under the "law of gravitation" a centripetal attracting force which varies inversely as the square of the distance, any particle of a fluid envelope on the equator will have a *tendency* to a greater *angular* velocity than that possessed by a particle situated nearer to either pole, and that by the perturbing

action of other bodies of the system an actual difference of *angular* velocity is developed. I hold that this difference of velocity will be productive of vortices in a fluid envelope, and that these vortices will be subject to a periodicity dependent upon the periodic variation of the perturbing force; *i. e.*, mainly upon the the periodic time of the perturbing body. It is obvious that the direction of rotation of these vortices will be dependent upon the direction of the angular velocity of the matter in which they are formed, and upon which side of the equator they are situate; thus, if the velocity be eastward and the vortex on the north side of the equatorial circle, the vortical rotation must be in a direction contrary to that in which the hands of a watch move, and the rotation of a vortex on the south side of the equator, will be in an oposite direction, or with the hands of a watch. I hold that, in the fluid envelope of the sun, these vortices are the sun-spots, and that, in the fluid envelope of the earth, *i. e.*, the atmosphere, they are the rotary storms. In a solid envelope such as the earth's crust, they will be torsional strains and any relaxation of the solid matter, under this stress will cause what is called an "earthquake."

The fundamental principles upon which I base the whole fabric of proof of the truth of the aforesaid hypotheses, and which can, I think, be regarded as axiomatic, may be succinctly stated as follows: First; An infinitesimal particle of solar matter rotating around the Sun's axis is subject to the action of solar gravitation, and the latter force, in conjunction with the *linear* velocity of rotation, makes the particle as really a planet as is the mighty Jupiter. Second; In like manner, each infinitesimal particle of terrestial matter rotating around the axis of the earth, and subject to the latter's attractive force, is as really a satellite as the moon. Third; That the same is true of any particle on any planet. Fourth; That each particle moving, or rather endeavoring to move in its respective orbit is subject to perturbation by other bodies of the solar system, in the same manner as is any planet or satellite.

As stated above, it is necessary, in order that these hypotheses may be entitled to a proper consideration, to submit them to a rigorous mathematical investigation; it is also obvious that the proper course of procedure is to first com-

pute the orbit of a particle of either solar or planetary matter situated at any known distance from the center of attraction, and endowed with a known *linear* velocity.

To do so it is necessary to have recourse to the general equations which express the several functions of orbital motion. From the fundamental equations of planetary motion are derived the following well known expressions:

$$\frac{V^2 r^2 \sin^2 \phi}{k^2} = p. \qquad (1)$$

In this equation, V represents the *linear* velocity of any body, great or small, moving in an orbit around the center of gravity of an attracting mass; r is the radius-vector of the body, or its distance from the center of attraction; ϕ is the angle which the direction of the linear velocity makes with the radius-vector; and k^2 is the unit of acceleration, or the acceleration impressed in unit time, upon any body at unit distance from the center of an attracting mass by the latter's "force of gravity." The value of k^2 is determined by the equation

$$k^2 = \frac{4\pi^2 a^3}{t^2 (1+m)} \qquad (2)$$

When the acceleration due to the sun is to be considered, a may represent the mean distance of any planet, and t its period of revolution in the orbit.

When the acceleration produced by the mass of any planet is to be computed from equation (2), a may represent the mean distance of any satellite revolving around the planet, and t will be the period of revolution of the satellite. As is well known, the mean distance of the earth is taken as the unit of distance, for the purpose of determining the acceleration due to the sun's mass, and the value of t is the sidereal year. The value of k thus determined is the well-known constant log 8.2355814. In order to obtain k for the purpose of determining the orbit of a particle of terrestrial matter, we must use the mean distance of the moon, as the unit of distance, and t will be the time of the moon's sidereal revolution, expressed in mean solar days, the day being taken as the unit of time. For the orbit of a particle on Mars, Jupiter, Saturn or Uranus I take the mean distance of the *first* satellite of each planet, and the corresponding period of revolution, but any

other satellite can be used for the determination of k. As the rotation period of Neptune is unknown, we cannot determine the orbit of a particle upon that planet, by this method.

The *linear* velocity, V, in equation (1) is determined for the sun or for any planet, from the respective rotation periods and circumferences of these bodies. The unit of time being the mean solar day, the *linear* velocity must be expressed accordingly. The value of r in equation (1) will, in the case of a particle upon the surface, be the value of the radius of the sun or of any planet under consideration. The direction of the velocity in the case of a particle on the circumference will, of course, be at any instant, at a right angle to the radius; therefore sin $\psi=1$.

The quantity, p, in the second member of equation (1), is the semi-parameter of the orbit, or the ordinate at the focus, if we take the major-axis as the line of abscissæ. Having by means of the above mentioned known quantities, determined the value of p, the other principal elements of the orbit of a particle can be derived from the following equations:

$$a=\frac{k^2}{\frac{2k^2}{r}-V^2} \qquad (3)$$

$$e=\sqrt{1-\frac{p}{a}} \qquad (4)$$

$$q=\frac{p}{1+e} \qquad (5)$$

In these equations, a represents the semi-axis major of the orbit of the particle, e is the eccentricity of the orbit, and q is, in the case of the sun, the perihelion distance, and in the case of the earth, the distance of the perigee; while for any other planet, it represents an analogous quantity. The above written equations are general and applicable to all cosmical bodies, but for sake of illustration I purpose to apply them first to the case of a terrestrial particle, because, in this wise, we can most readily take into account and compare the results derived from theory with those determined, independently, from actual observation and measurement.

Conceive the earth to be a *sphere* whose radius is equal to the known polar radius, and that this sphere is at rest; *i. e.*, that it does not revolve upon an axis; then let a motion

of rotation, equal to that which is actually observed, be instantaneously impressed upon it; the problem now presented for solution may be stated as follows: What form of orbit will an infinitesimal particle of matter, situate upon the surface of the earth, tend to describe under the joint action of terrestrial gravitation and the *linear* velocity due to rotation? We see, from the above equations, that the form of orbit is dependent upon the value of the semi-parameter p. Considering equation (1), we preceive that, when V is 0, p also becomes 0, in other words the particle will simply be drawn, in a *straight* line, toward the centre of gravity or the focus. We know that at the poles $V=0$, and that its maximum value is on the equator, therefore the effect produced by rotation, upon a particle situated on the circumference of the equatorial circle, will be considered first.

For the determination of the value of k, from equation (2), we take the mean distance of the moon as unity, or $a = 1$, the sidereal period of the moon as 27.32166 days, and the lunar mass as .012285, the mass of the earth being unity. The resulting value of k will be expressed by a number whose log is 9.3616728.

The equatorial *linear* velocity V, of a terrestrial particle when the equatorial circumference is taken as a function of the polar radius r, will be represented by a number whose log is 9.0178790, and the value of r by a number whose log is 8.2185113. The value of p, derived from the substition of the squares of these quantities in equation (1), will be a number whose log is -5.7494350; this is, of course, in terms of the moon's mean distance. The value of p in miles will therefore be found by adding to the last mentioned logarithm the logarithm of the moon's mean distance in miles, or 5.3780691; this will give log 1.1275041, or 13,412 miles, as the value of the semi-parameter. The latter becoming thus known, we can, by means of equations (3), (4), and (5), obtain the values of the semi-axis major, the eccentricity and the distance of the perigee. Equation (4) shows the orbit to be an ellipse of great eccentricity, in fact one very closely approximating a straight line. The semi-axis major, $a = 1978.28$ miles, $e = .996604$, and $q = 6.72$ miles. Some interesting and important results flow from a consideration of the orbit represented by these quantities.

Should this orbit be drawn to a scale suitable for the pages of this magazine it would appear to deviate but little from a straight line, therefore in the following diagrams the proportions of the ellipse are greatly exaggerated for the purpose of illustration.

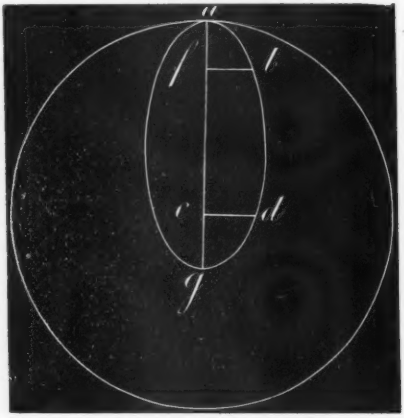


FIG. 1.

Let the circle in the above depicted figures represent the equatorial circumference of the earth, regarding the latter as a sphere whose radius is equal to the polar radius, and which is at rest. Let *a* be a particle on this circumference, and let it be instantaneously impressed with a motion directed toward the right, and equal to the eastward rotational velocity actually observed, then, if it were not constrained by the resistance of the terrestrial substance to remain upon the surface, the particle would describe the ellipse whose elements are given above, and which is depicted in *Fig.* 1. It can be readily seen that instead of falling directly to the "centre of gravity," at *c*, the particle would, after falling through the quadrant, be found at *d*, or the extremity of the semi-parameter *p*, which is represented in *Fig.* 1, by the line *cd*. This line may be regarded as representing a radial force, or a force directly upward from the earth's centre and urging the particle outward from the surface. We also see that at the other focus, *f*, of the ellipse, there is another semi-parameter, *fb*, equal to *cd*, which may

also be considered as representing a force. It is to be noted especially that this latter has its origin at the focus *f*, which is, according to the determination above mentioned, 6.72 miles below the circumference, and that it is, therefore, *not* a tangential force; this fact is to be kept clearly in mind, because for the purpose of substantiating the views which I have enunciated it is a vital one. If we now consider a particle at *a* in *Fig.* 2, a quadrant farther advanced than the particle in *Fig.* 1, we may regard it as being acted upon in the same manner, and to the same degree, as is the particle at *a* in *Fig.* 1.

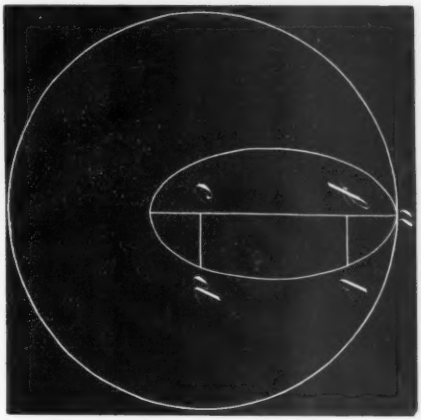


FIG. 2.

The orbit of the former particle will be an ellipse whose elements have the same values as those of the ellipse shown in *Fig.* 1, but the semi-axis major of this second ellipse, will be at a right angle to the corresponding axis of the first ellipse; therefore the semi-parameters representing the forces, regarding these as existing simultaneously, will also be at a right angle to each other. In *Fig.* 1, we see the particle *a* at the *beginning*, and in *Fig.* 2, at the *end* of a quadrant. In the case of continuous rotation, the particle will be, at the same instant, at the beginning of one quadrant and at the end of another; therefore the two equal forces represented by the semi-parameters, at a right angle to each other, may be superposed,—one will be the radial or uplifting force

cd, and the other the force *fb*, proceeding from the focus *f*. The mathematical reader will probably say that the forces so found are only the radial and the tangential forces which have been heretofore considered in the discussion of the effects produced by the rotation of the earth, and, in the main, this reader would be right, but he must also notice that what is called the tangent force, is not, in this case, such. The effect of the radial force *cd* is, as has been stated, to move the particle at *a* on the equatorial circumference upward to a distance of 13.412 miles, which is the value of *p*, derived from equation (1). If we now consider the case of particles situated at an infinite number of points around the equatorial circumference, it is obvious that they will all be acted upon, in the same manner, and to the same degree, as is the particle we have just considered. The plane of the orbit shown in *Fig.* 1 lies in the plane of the equator; let us now consider it to be moved through all degrees of inclination, from 0° to 90° on either side of the equator, the major axis of the orbit lying throughout in a meridian plane. We see from (1) that the value of p (r, k and *sin* remaining constant) will vary as V^2. We also know that the linear rotational velocity V varies from a maximum at the equator to 0 at the poles; therefore the value of p, or the uplifting force, will be a maximum, or 13.412 miles at the equator and 0 at the poles. It is manifest, also, that the direction of the orbital velocity of the particle at *a*, on the equator, is eastward, parallel to the plane of the equator, but that as the inclination increases, the direction of this velocity will change, so that in latitude 90° it will be at a right angle to the equatorial plane. Just as we have considered an infinite number of particles around the equatorial circumference, so we may consider an infinite number of particles on a meridian circumference, and also an infinite number of these circumferences. This done, we will have considered an infinite number of particles covering the whole surface of the earth. I now claim that we have, in this process, a means of determining the figure of the earth, and not only the figure of the latter but also that of any other cosmical body whose radius r, *linear* rotational velocity V, and constant of acceleration k^2, are known. For although we have considered only the

surface particles, the same reasoning applies to all others, and the effect upon all is expressed generally by equation (1). Furthermore, it is *not* necessary that we should take into account the density of the various strata of the earth, or of any other body, in order to obtain a knowledge of its figure, for all the infinitesimal particles constituting these bodies may be regarded as of equal density and all are acted upon in an analogous manner according to equation (1). Although the *rationale* of the above claims may be apparent to many, I bear in mind the condition referred to at the beginning of this article, viz., that in order to entitle the hypotheses herein advanced to the right of consideration by the scientific world, it is necessary that they should be found concordant with the results derived from observation. Therefore I have computed by means of the first equation the figure not only of the earth, but also of the Sun, Mars, Jupiter, Saturn and Uranus, from their known rotational velocities, radii and accelerating forces, the last quantities being determined from equation (2), by means of the motions and distances of their respective *first* satellites.

In the case of the earth, I have shown that equation (1) gives 13.412 miles as the value of p or the uplifting force.

Taking Clarke's value of the polar radius as 3949.830 miles, the compression c (taken in the sense $c = \frac{a-b}{b}$, in which a is the equatorial and b the polar radius), will be $\frac{13.412}{3949.830} = \frac{1}{294.5}$. From an exhaustive discussion of all measured arcs of meridian, Clarke has obtained $\frac{1}{294.0}$ as the value of the compression. This is certainly a very close agreement with the result derived by means of my method, for it represents a difference of only 158 feet in the value of the equatorial radii determined by the two different methods. The determination of the compression, by means of the pendulum, differs considerably from that derived from arcs of meridian, the value of c so obtained being $\frac{1}{288.5}$. Pendulum observations have been made in great numbers and very carefully, so that the probability of any material difference being due to observational error is small; the discrepancy has, therefore, been attributed principally to the effect of local attraction upon the motion of the pendulum, but I purpose showing, further on, that it is due, not to errors of observa-

tion, or those attributable to local attraction, although both probably exist, but to another cause simple in itself, but very essential to a proper determination of the figure of the earth from pendulum vibrations. I will here anticipate a little, and say that when this cause is taken into account, the pendulum value of the compression becomes $\frac{1}{293.5}$, a quantity *practically* the same as the two already obtained. What we have to consider now is simply the effect of rotation upon the sun and upon the planets above mentioned. Taking the best known values of the respective radii, rotational velocities, and the motions of the bodies revolving around the sun and the planets aforesaid, together with the distances of these bodies from the respective centres of gravity around which they revolve, I have obtained the results tabulated below:

	Sun.	Earth.	Mars.	Jupiter.	Saturn.	Uranus.
Polar radius (miles)..	426,441	3949.83	2,180	39,736	32,064	15,414
Computed value of p,	9	13.41	1	2,687	3,004	1,210
Resulting equatorial radius.....	426,450	3963.24	2,181	42,423	35,068	16,624
Computed compression, taken, $c=\frac{a-b}{a}$	$\frac{1}{49738}$	$\frac{1}{295.5}$	$\frac{1}{2181}$	$\frac{1}{15.8}$	$\frac{1}{11.7}$	$\frac{1}{13.7}$
Observed compression,	.....	$\left\{\begin{matrix}\frac{1}{295.0}\\ \frac{1}{294.5}\end{matrix}\right.$	.....	$\frac{1}{16.7}$	$\frac{1}{9.4}$	.....

It is obvious that all bodies rotating upon an axis are subject to the action of "centrifugal force," which tends to increase the equatorial diameter of a fluid body. The sun is such a body, and it must, therefore, have an equatorial diameter longer than its polar, but thousands of carefully made observations have disclosed no difference between the diameters. The results for the sun tabulated above show why this is so, for the value of the compression derived by my method is only $\frac{1}{49738}$, and this gives as the difference of the diameters, in angular measure, only 0″.04, a quantity so small that instrumental measures cannot well detect it.

In the case of the earth, we see that the theoretical compression is $\frac{1}{295.5}$ while the observed values are $\frac{1}{295.0}$ and $\frac{1}{294.5}$, the first of these values being that derived from arcs of meridian, and the second that obtained from pendulum vibrations. The last is, as stated, a corrected result, and the reasons for making the correction will be shown further on.

The difference between my theoretical value and that derived from the arcs is only 128 feet, and the difference between it and the pendulum result (corrected) is only 234 feet in the value of the equatorial radius. In the case of Mars the observations are not at all concordant, some observers claiming the existence of an appreciable difference between the diameters, others seeing none at all, while still other few assert that the polar radius is the longer. The determination by my method gives $\frac{1}{2181}$ as the value of the compression. If we consider the value $\frac{1}{60}$, which has been assigned by some, we find that it amounts to only 0″.10 between the angular diameters. It is a quantity too small to be observed with any certainty. Therefore I think that the theoretical value which I have found is more likely to be the true one. I have used in the computation both Phobos and Deimos, and both processes give the same result, viz., a difference of one mile between the radii.

The difference between the theoretical and the observed values of the diameters in the case of Jupiter amounts to only 0″.12, the greater part of which discrepancy may, I think, be justly attributed to errors of observation.

In the case of Saturn the difference between theory and observation amounts to 0″.36. A portion of this may be properly attributed to observational error, but I think that a large part of it is due to another cause. Paradoxical as the statement may seem, if there were not a real difference between the theoretical and the observed value, the theory would be at fault; this can be made evident by a consideration of equation (1). We see that p, or the measure of the compression varies inversely as k^2, but k is determined from the motion and the mean distance of the first satellite which revolves outside the *rings* of Saturn; therefore the value of k which I have used involves the mass, not only of the ball of Saturn, but of the innumerable satellites which constitute the rings as well, while the value of k which should be used is that which involves the mass of the ball only. For the particles whose orbits are to be computed constitute the ball, and the action of the matter of the rings upon them will be only a perturbative one. It is apparent that the former value of k is greater than the latter, and that therefore p, or the theoretical compression, should be less than the

observed, just as I have found it to be. If there were no error of observation this difference would furnish a measure of the mass of the rings.

In the case of Uranus, there is, so far as I know, no instrumental determination of the value of the compression, and, furthermore, the rotational velocity is only approximately known. Using the velocity assigned, I find a theoretical compression whose value is $\frac{1}{13.7}$; this gives as the angular difference between the diameters only 0″.28. If the position of the axis were well known, and a great number of measurements very carefully made, I think that a compression approximating the above would be disclosed, but the total amount is so small that a very accurate determination is impossible. Since Mercury and Venus have no known satellites, the above method cannot be used in its entirety for the determination of the compression of these planets; but since their respective masses are known approximately a modified method, viz., one of comparison with the earth's compression can be used for this purpose. Let the earth's mass, radius and rotational period be each equal to unity, and the corresponding quantities for Mercury and Venus be expressed in terms of the former quantities, by m, a and b. A consideration of equation (1) will show that the value of the compression c may be obtained from the following equation:

$$c = \frac{13.412a^4}{mb^2r} \quad (6)$$

In this equation r represents the radius of the planet, expressed in miles. From (6) I have obtained for the compression of Mercury $\frac{1}{338}$, and for Venus $\frac{1}{291}$; the first quantity represents a difference between the angular diameters of Mercury of only 0.″02, and the latter a difference of only 0.″06 between the diameters of Venus, quantities too small to be accurately observed.

It is obvious that, by means of my method, an accurate knowledge of the figure of the earth can be derived from linear measurements of arcs of *longitude* either on the equator or reduced to it. Such arcs would furnish a value of the equatorial radius, and this in connection with the velocity v, and k, would give a value of the compression closely approximating the true one. This again will give a near ap-

proximation to the value of the *polar* radius from which a more accurate value of the compression can be determined. Three approximations will suffice to give a true value of the last named quantity.

(To be Continued.)

DEARBORN OBSERVATORY.

H. A. JOHNSON, M. D.*

The Chicago Astronomical Society, after mature consideration, decided to commit to the Northwestern University the care and use of the Dearborn Observatory. The arrangements by which the location of the Observatory and the incorporation of it as a part of the university has been accomplished are mutually satisfactory. As a result of these arrangements we have met to-day to lay the corner-stone of a building which we hope and believe will become known wherever science is cultivated, and especially wherever the heavens are studied. There is not time, nor perhaps is this the fitting place to enter upon a historical statement of the great telescope. It is sufficient to say that at the time it was secured for the Observatory it was the largest in existence; that is, the largest refracting telescope. Although there are now a few instruments with larger object glasses than this, this one still remains among the very best, among the most reliable and most powerful in existence. It has been in use since it was first mounted, and the contributions which have been made to our knowledge of celestial phenomena through its revelations have been recognized by all interested in this department of science. I may mention especially the studies of the varying condition of the surface of the planet Jupiter, carried on through a series of years. These have been published in the reports of the society, and are a lasting monument to the skill and industry of the director, Professor Hough.

The relations of the society to the university do not relieve us of responsibility, nor diminish our interest in the future of the observatory. We trust that the liberality

* Address delivered by the president of the Chicago Astronomical Society at the laying of the corner stone of the new building for Dearborn Observatory at Evanston, Ill., Thursday, June 24, 1888.

that has secured for the instrument a suitable building and mounting, and the conveniences for profitable use here will be exercised to meet the increased needs that shall be developed. These needs will come. They will always be growing. It is only by relegating the instrument to the list of unused things that its wants can remain stationary. We trust that some liberal-minded friend of a wider and more liberal education will provide for the astronomical department an endowment which shall make this institution as permanent as are some of the older observatories of this and other countries. This requires money, but money put into this fund will pay more than it now commands in the business markets of the world.

We congratulate the Northwestern University upon this addition to the means of culture and influence which it is creating here upon the borders of this beautiful lake. It is within my memory that these grounds were transferred from the domain of wild nature to classic shades, academic groves. I once stood upon yonder bluff and looked out upon the quiet lake. There a little way down the country road was a farm house, and that was all there was of the city of Evanston, and all that there promised to be at that time. I had come to make a professional visit to a poor woman, the farmer's wife, and strayed out among the trees and gazed upon the lake while thinking what I might do for my patient. No one then thought of a future city amid these groves. Chicago itself had barely 30,000 inhabitants, and a prophet who should have foretold the realities of to-day would have been regarded as—well, as a very pronounced "Chicago man"—that is a little "cranky." I believe that my old teacher, the venerable Dr. John Evans, was among the most enthusiastic believers in the greatness of Chicago. It was the outcome of his enthusiasm, his far-seeing wisdom, that these magnificent grounds were consecrated for all coming time to the noble uses of a higher education. His monument is not alone in the name which this city bears. It is in these clustered halls, these temples of literature, of science, of art, of religion, and in the wider, more powerful, and vastly better influence which, in the persons of the alumni of this institution, permeates all of this broad land.

The occasion which has called us together is of peculiar interest. Why have we determined to build here among these classic shades and in connection with these seats of learning, a temple to the stars, perhaps I might say to Jupiter? What is the significance in these days of practical things of this addition to the university? Is there any use to which it may be put? Will it in any way help the student in his work of preparation for the duties of life? These are questions that will naturally occur to those who look upon every kind of learning from the standpoint of utilitarianism. If we were to admit that all learning should be judged by the help which it brings to the material interests of life, there would still be found a sufficient answer to these interrogatories. It is not, however, in this narrow sense that a university should be judged. It has a wider range, a broader field, a richer harvest of truth and usefulness than simple food, shelter and raiment, than a provision for the machinery of business, and we trust that this institution will serve this wider purpose. It is possible, nevertheless, to show that the studies of the astronomer, the use of instruments of precision in the observation of the celestial bodies, and the abstruse mathematical calculations by which these observations are translated into the language of common life, that these are all helpful in the affairs of time and sense. Perhaps we are hardly aware of the very great importance of accuracy as to time in many of the business transactions of civilized communities. In fact this precision is one of the indications of intellectual and social progress. It enters into all of the industrial pursuits. It constitutes an important factor in all our commercial transactions; and especially in these days of eager, anxious haste, it furnishes the condition of safety, in fact the only substantial condition of safety. The astronomer in his dome, the world shut out, with his telescope pointed away from earth, while all the heavenly hosts in rapid succession march across his field of vision, determines the time-table of the skies, the place and hour when and where suns and planets shall meet and pass a thousand years to come.

These studies furnish the data, and the only data, upon which the dispatcher of terrestrial trains conducts with comparative safety the millions of human beings to and fro,

from sea to sea, and over and through this interminable network of railways and steamships, a network which has been drawn closely around all whom we love, all who love us, and all who in any way are concerned in the welfare of the human race. It is accuracy, precision, certainty, the conviction that the clock in the railway office, the time-keeper in the business exchange, the watch of the conductor and engineer and the chronometer of the master of the great steamship, that all these markers of duration are in accord, that they are all right, that gives a sense of security, of restfulness which nothing else could give. Accuracy in time is the foundation of accuracy in every other matter. It is promotive of truthfulness in every other respect. In some sense, then, the Observatory is a moral institution, an ally of the biblical institute. The great telescope is a detective, a sure witness, a trustful, unchanging, unambiguous revealer of the secrets of nature. Its creed never changes. It has no favorites, and no enemies. It cannot be bribed. No threats intimidate it. Its revelations of the past are not myths, but veritable history. Its prophecies will surely be fulfilled. All this precision, all this certainty, all these helps in the affairs of practical life, are the outcome of astronomical work, and would be impossible without it.

It would be trite, perhaps, to refer to the studies connected with such institutions as a means of enlarging the scope of mental action and giving it a wider range of intellectual vision. Perhaps even such a view of the influence of astronomical investigation would by some be considered an objection to this class of studies for all except the very few whose lives are to be devoted to the especial work of time keeping. Such a view is in accord with the tendency of the age, which, as it seems to me, is to narrowness. It is true, this very fact gives a high degree of skill in a given pursuit, but it nevertheless dwarfs the powers of the individual in every other respect. The division of labor carried to the extreme, the tendency to an exaggerated specialism in the professions, the narrow line of studies pursued in some of our educational institutions where studies are selected with special reference to the work of the coming years, and before any general foundation has been laid down upon which such special studies ought to rest, all these may lead to great intensity.

Like the diamond drill, they may push on a narrow line to the very front of knowledge along that line, while all that lies parallel to it, and perhaps very near to it, remains unknown but connected with it. I confess I see with some regret this tendency, and I hail with satisfaction all these scientific additions to the university as in some sense corrective of the narrowness which the desire to make of every man a specialized machine seemes to necessitate.

The bearing of these studies upon the moral and religious elements of our being is only good. One who during his life has looked longingly and lovingly into the heavens exclaimed: "the undevout astronomer is mad." The contemplation of the divine wonders of the celestial vault leads the thought away from the small things of time and sense, and opens the eternal volume which must always be a companion to that written upon the rocks of Sinai. The nice balance of the universe, the order that comes out of apparent disorder, the infinite depths of space, the vast whirl of mighty suns to which our sun in its warmth and glory is but a spark, the far-off nebulæ, the star-dust that like the lights of a distant city gleam upon the very confines of the visible universe, these are all so many sources of inspiration. No wonder that old Chaldean shepherds, gazing into the heavens, were wise beyond their fellows; that they were "seers." All these sublime chambers of the infinite open before us we become, like the stars themselves, silent with awe. The words of the poet feebly give voice to our struggling thought:

> "What though in solemn silence all
> Move round this dark terrestrial ball;
> What though no real voice nor sound
> Amid those radiant orbs be found;
> In Reason's ear they all rejoice,
> And utter forth a glorious voice,
> Forever singing as they shine,
> The hand that made us is divine."

Opposition of Mars for 1888. L. Niesten, of the Royal Observatory of Brussels, has published a brief paper on the physical aspects of the planet Mars at opposition for 1888. Two plates accompany the paper.

THE EXISTENCE OF ALL-PERVADING ETHER PROVED BY EXPERIMENT.*

And now I want to spend a short time in explaining to you how the question has been decided. An illustrative example may make the question itself clearer, and so lead you to understand the answer better. In colloquial language we say that balloons, hot air, etc., rise because they are light. In old times this was stated more explicitly, and therefore much more clearly. It was said that they possessed a quality called "levity." "Levity" was opposed to "heaviness." Heaviness made things tend downwards, levity made things tend upwards. It was a sort of action at a distance. At least it would have required such an hypothesis if it had survived until it was known that heaviness was due to the action of the earth. I expect levity would have been attributed to the direct action of heaven. It was comparatively recently in the history of mankind that the rising of hot air, flames, etc., was attributed to the air. Everybody knew that there was air, but it was not supposed that the upward motion of flames was due to it. We now know that this and the rising of balloons are due to the difference of pressure at different levels in the air. In a similar way we have long known that there is an ether, an all-prevading medium, occupying all known space. Its existence is a necessary consequence of the undulatory theory of light. People who think a little, but not much, sometimes ask me, "Why do you believe in the ether? What's the good of it?" I ask them, "What becomes of light for the eight minutes after it has left the sun and before it reaches the earth?" When they consider that, they observe how necessary the ether is. If light took no time to come from the sun, there would be no need of the ether. That is a vibratory phenomenon, that is affected by matter it acts through—these could be explained by action at a distance very well. The phenomenon of interference would, however, require such complicated and curious laws of action at a distance as practically to put such an hypothesis out of court; or else be purely

* An extract from the Address of Professor G. P. Fitzgerald, M. A., F. R. S., President of the Section of Mathematics and Physical Science of the British Association, at its annual meeting in Bath for 1888.

mathematical expressions for wave propagation. In fact, anything except propagation in time is explicable by action at a distance. It is the same in the case of electro-magnetic actions. There were two hypotheses as to the causes of electro-magnetic actions. One attributed electric attraction to a property of a thing called electricity to attract at a distance, the other attributed it to a pull exerted by means of the ether, somewhat in the way that air pushes balloons up. We do not know what the structure of the ether is by means of which it can pull, but neither do we know what the structure of a piece of india-rubber is by means of which it can pull; and we might as well ignore the india-rubber, though we know a lot about the laws of its action, because we do not know its structure, as to ignore the ether because we do not know its structure. Anyway what was wanted was an experiment to decide between the hypothesis of direct action at a distance and of action by means of a medium. At the time that Clerk Maxwell delivered his address no experiment was known that could decide between the two hypotheses. Specific inductive capacity, the action of intervening matter, the delay in telegraphing, the time propagation of electro-magnetic actions by means of conducting material—these were known, but he knew that they could be explained by means of action at a distance, and had been so explained. Waves in a conductor do not necessarily postulate action through a medium such as ether. When we are dealing with a conductor and a thing called electricity running over its surface, we are, of course, postulating a medium on or in the conductor, but not outside of it, which is the special point at issue. Clerk Maxwell *believed* that just as the same air that transmits sound is able by differences of pressure—*i. e.* by means of its energy per unit volume—to move bodies immersed in it, so the same ether that transmits light causes electrified bodies to move by means of its energy per unit volume. He believed this, but there was no experiment known then to decide between this hypothesis and that of direct action at a distance. As I have endeavored to impress upon you, no *experimentum crucis* between the hypotheses is possible except an experiment proving propagation in time, either directly, or indirectly by an experiment exhibiting phenomena like those of the interference

of light. A theorist may speak of propagation of actions in time without talking of a medium. This is all very well in mathematical formulæ, but, as in the case of light we must consider what becomes of it after it has left the sun and before it reaches the earth, so every hypothesis assuming action in time really postulates a medium whether we talk about it or not. There are some difficulties surrounding the complete interpretation of some of Hertz's experiments. The conditions are complicated, but I confidently expect that they will lead to a decision on most of the outstanding questions on the theory of electro-magnetic action. However, there is no doubt that he has observed the interference of electro-magnetic waves quite analogous to those of light, and that he has proved that electro-magnetic actions are propagated in air with the velocity of light. By a beautiful device Hertz has produced rapidly alternating currents of such frequency that their wave length is only about 2 metres. I may pause for a minute to call your attention to what that means. These waves are propagated 300,000 kilometers in a second. If they vibrated 300,000 times a second, the waves would be each a kilometer long. This rate of vibration is much higher than the highest audible note, and yet the waves are much too long to be manageable. We want a vibration about a thousand times as fast again with waves about a metre long. Hertz produced such vibrations vibrating more than 100,000,000 times a second. That is, there are as many vibrations in one second as there are seconds—in a day? No, far more. In a week? No, more even than that. The pendulum of a clock ticking seconds would have to vibrate for four months before it would vibrate as often as one of Hertz's vibrators vibrates in one second. And how did he detect the vibrations and their interference? He could not see them; they are much too slow for that; they should go about a million times as fast again to be visible. He could not hear them; they are much too quick for that. If they went a million times more slowly they would be well heard. He made use of the principle of resonance. You all understand how, by a succession of well-timed small impulses a large vibration may be set up. It explains many things from speech to spectrum analysis. It is related that a former Marquess of Waterford used the principle to over-

turn lamp-posts—his ambition soared above knocker-wrenching. So that it is a principle known to others besides scientific men. Hertz constructed a circuit whose period of vibration for electric currents was the same as that of his generating vibrator, and he was able to see sparks, due to the induced vibration, leaping across a small air space in the resonant circuit. The well-timed electrical impulses broke down the air resistance just as those of my Lord of Waterford broke down the lamp-post. The combination of a vibrating generating circuit with a resonant receiving circuit is one that I spoke of at the meeting of the British Association at Southport as one by which this very question might be studied. At the time I did not see any feasible way of detecting the induced resonance: I did not anticipate that it could produce sparks. By its means, however, Hertz has been able to observe the interference between waves incident on a wall and the reflected waves. He placed his generating vibrator several wave-lengths away from a wall, and placed the receiving resonant circuit between the generator and the wall, and in this air-space he was able to observe that at some points there were hardly any induced sparks, but at other and greater distances from his generator they reappeared, to disappear again in regular succession at equal intervals between his generator and the wall. It is exactly the same phenomenon as what are known as Lloyd's bands in optics, which are due to the interference between a direct and a reflected wave. It follows hence that, just as Young's and Fresnel's researches on the interference of light prove the undulatory theory of optics, so Hertz's experiment proves the ethereal theory of electro-magnetism. It is a splendid result. Henceforth I hope no learner will fail to be impressed with the theory—hypothesis no longer—that electro-magnetic actions are due to a medium pervading all known space, and that it is the same medium as the one by which light is propagated, that non-conductors can, and probably always do, as Professor Poynting has taught us, transmit electro-magnetic energy. By means of variable currents energy *is* propagated into space with the velocity of light. The rotation of the earth is being slowly stopped by the diurnal rotation of its magnetic poles. This seems a hopeful direction in which to

look for an explanation of the secular precession of terrestrial magnetism. It is quite different from Edlund's curious hypothesis that free space is a perfect conductor. If this were true there would be a pair of great anti-poles outside the air, and terrestrial magnetism would not be much like what it is, and I think the earth would have stopped rotating long ago. With alternating currents we *do* propagate energy through non-conductors. It seems almost as if our future telegraph cables would be pipes. Just as the long sound waves in speaking tubes go round corners, so these electro-magnetic waves go round corners if they are not too sharp. Professor Lodge will probably have something to tell us on this point in connection with lightning conductors. The silvered glass bars used by surgeons to conduct light are exactly what I am describing. They are a glass, a non-conducting, and therefore transparent, bar surrounded by a conducting, and therefore opaque silver sheath, and they transmit the rapidly alternating currents we call light. There would not be the same difficulty in utilizing the energy of these electro-magnetic waves as in utilizing radiant heat. Having all the vibrations of the same period we might utilize Hertz's resonating circuits, and in any case the second law of thermodynamics would not trouble us when we could practically attain the absolute zero of these, as compared with heat long-period vibrations.

We seem to be approaching a theory as to the structure of the ether. There are difficulties from diffusion in the simple theory that it is fluid full of motion, a sort of vortex sponge. There were similar difficulties in the wave theory of light owing to wave propagation round corners, and there is as great a difficulty in the jelly theory of the ether arising from the freedom of motion of matter through it. It may be found that there is diffusion, or it may be found that there are polarized distributions of fluid kinetic energy which are not unstable when the surfaces are fixed: more than one such is known. Osborne Reynolds has pointed out another, though in my opinion less hopeful, direction in which to look for a theory of the ether. Hard particles are abominations. Perhaps the impenetrability of a vortex would suffice. Oliver Lodge speaks confidently of a sort of chemical union of two opposite kinds of elements forming the ether. The

opposite sides of a vortex ring might perchance suit, or maybe the ether, after all, is but an atmosphere of some infra-hydrogen element; these two latter hypotheses may both come to the same thing. Anyway we are learning daily what sort of properties the ether must have. It must be the means of propagation of light; it must be the means by which electric and magnetic forces exist; it should explain chemical actions, and if possible gravity.

On the vortex-sponge theory of the ether there is no real difficulty by reason of complexity why it should not explain chemical actions. In fact, there is every reason to expect very much more complex actions would take place at distances comparable with the size of the vortices than at the distances at which we study the simple phenomena of electro magnetism. Indeed, if vortices can make a small piece of a strong elastic solid, we can make watches and build steam-engines and any amount of complex machinery, so that complexity can be no essential difficulty. Similarly the instantaneous propagation of gravity, if it exists, is not an essential difficulty, for vortices each occupy all space, and they act on one another simultaneously everywhere. The theory that material atoms are simple vortex-rings in a perfect liquid otherwise unmoving is insufficient, but with the innumerable possibilities of fluid motion it seems almost impossible but that an explanation of the properties of the universe will be found in this conception. Anything purporting to be an explanation founded on such ideas as "an inherent property of matter to attract," or building up big elastic solids out of little ones, is not of the nature of an ultimate explanation at all; it can only be a temporary stopping-place. There are metaphysical grounds, too, for reducing matter to motion and potential to kinetic energy.

MR. J. A. BRASHEAR'S EUROPEAN TRIP.*

At London I visited the rooms of the Royal Society and here I had a *royal* time with Professor Dewar who, with

* On Mr. Brashear's return from Europe, we asked him to tell us something about his trip, in informal way, for we knew he would be exceedingly busy after vacation absence. His reply contains so many things of interest that we share it with our readers, though not especially prepared for publication.

Professor Liveing, is carrying on some most interesting researches on the spectra of the gases, and particularly the spectrum of water vapor in high vacuo, in perhaps the largest vessels that have ever been used for the purpose. Some remarkable discharges were witnessed, or rather one would call them streams of electric energy having all the appearances of comets when nearing the sun, and Professor Dewar seems to think that these experiments may have an important bearing in the solution of cometic phenomena.

At the Royal Institute I had the privilege of an examination of many of the treasures of the museum, where are stored the models and apparatus of Sir Humphrey Davy, Faraday and Cavendish.

While in London I had the pleasure of visiting Dr. Huggins at his Observatory on Upper Tulse Hill. Here we found the good Doctor and his charming wife (Mrs. B. said she came very near to her idea of an angel) ready to show us his grand equipment for celestial spectroscopy that is perhaps not excelled anywhere. The Doctor has two telescopes mounted on the same stand after Grubb's plan, and there are so many accessories to his outfit that it would take a large volume to describe them. Mrs. Huggins handles these instruments with perfect ease, and her interest in the work has certainly been a large factor in the wonderful results that have been achieved by the Director of the "Upper Tulse Hill Observatory." We had the pleasure of meeting Mr. E. B. Knobel, the secretary of the Royal Astronomical Society, at Dr. Huggins', and the delightful "tea" we sat down to in that charming "library" will not soon be forgotten. At Cambridge Professor Liveing gave us every facility to see what they are doing. A new chemical laboratory is about completed at St. John's College, in which is to be placed a concave grating spectroscope. This grating (which was 21 feet radius) I had the pleasure of carrying over with me. You have no idea how much pleasure I had here in examining one of the largest of the reflecting telescopes made by Sir Isaac Newton and kept in a good state of preservation. I was allowed the rare privilege of taking out the speculum and measuring its constants, examining the character of the metal, its polish, etc. The polish is still quite good and would show bright objects fairly well.

At Cambridge we met the venerable Professor Adams and his good wife, and renewed a most pleasant acquaintance formed at Philadelphia in 1884. Professor Adams is still in the harness, and is one of those grand men whom the world will miss when they have "finished their course."

But I must hasten over to Paris where I had a "glorious" time with "glorious" men, and I cannot refrain from saying that the courteous secretary of the Paris Observatory, Mr. Fraissinet, did everything in his power to make my stay pleasant. A day was spent with Dr. J. Janssen and his delightful family at the great "Observatory" of Meudon, where at present no less than *three* large new observatories are being completed. The old chateau of the first Prince Napoleon is now being changed into a great Observatory, the dimensions of which will be but a few feet less than the Lick. The great new refractor is to be placed in this. In one of the other observatories a reflecting telescope of one meter aperture and three meters focal length is to be placed, for use in photographing the nebulæ, comets, and other celestial objects requiring large apertures, and in the third, one of the standard thirteen-inch photographic refractors is to be set up. All these instruments are under way—the optical parts being made by the Henry Brothers, and the mechanical parts by M. Gautier.

Of course every one will know I was particularly interested in the Brothers Henry and their work. Here a most hearty welcome awaited us, and to say that we enjoyed it hugely is to put it very mildly.

These two devotees of science work by themselves with some help from their father, whom they hold in the highest reverence, and he is a grand old man, and I confess I never left a place more reluctantly than I did the home of these whole-souled men.

At the time of our visit they were working a 13-inch photographic objective by their usual method of paper polishing of which they seem to be complete masters. They were so totally unselfish that they showed me the entire *modus operandi*. They are doing some large work, for, besides the photographic and other large objectives, they are engaged on several large instruments known as the Equatorial Coudé, one of which is to be 23 inches clear aperture. I saw

in their shops a 40-inch plane mirror, 7 inches thick, a beautiful piece of work, and I had the pleasure of examining a number of their optical surfaces with them. All I fear of these grand fellows is, that they are *working beyond their limit*, for not only is every hour of the day spent at their optical work, but every night with a clear sky finds them at their post at the Observatory carrying out their part of the photographic chart of the heavens, and we all know how well this part of their work has been done. I could fill a dozen sheets with what I saw here, but I must desist. I had received a very cordial invitation from Dr. Loewy to make some observations with the Equatorial Coudé, and of course availed myself of the privilege, as this was one of my desires in going to Paris. When I called the doctor was making some studies of the constants of refraction by his new method, which is well known to astronomers, and notwithstanding the fact that here was an additional pair of mirrors added to the telescope, the image of the stars in the field was all that could be desired. It is understood, however, that the reflected image of each star comes from three mirrors, and not from four. I had every facility afforded me to study the construction of these instruments, both at the Observatory and at the works of M. Gautier, who was kind enough to show me all the drawings and the work under way.

While in Paris I visited the optical glass works of M. Mantois, successor to Feil. M. Mantois has reconstructed the works, and he has now everything arranged so systematically that it is a genuine pleasure to go into his warehouse or his works. Every kind of glass has its department and is so arranged that if you desire first, second or third grade, of any density or index, it can be at once pointed out to you. I had the pleasure of examining many discs from 6 inches to 30 inches diameter, as well as a huge mass that M. Mantois is preparing for the Paris exhibition next year. I have not the least doubt in my mind that the mantle of Feil and his predecessors has fallen upon M. Mantois, who will not only wear it with honor to himself, but will make it all the more valuable by the work he will do in the future. But I must close this already too lengthy letter, and leave the subsequent part of my pleasant experience for another

letter. I cannot forget the kindness of Dr. Janssen, Professor Deslandres, M. Admiral Mouchez, M. Fraissinet, MM. Paul and Prosper Henry, M. Loewy, M. Gautier and others who made my stay in Paris so pleasant and profitable, and I trust the genuine spirit of unselfishness that I found in these lovers of the good and beautiful, will always be emulated by their brethren on this side of the Atlantic.

MEAN PARALLAX OF FIRST MAGNITUDE STARS.*

Since my last report the series of observations on the parallaxes of the ten stars of the first magnitude in the Northern Hemisphere has been brought to a close. It may seem worth while to mention in brief here the results arrived at, in advance of their detailed publication in our Transactions. They are as follows:

Star.	Parallax.	Prob. Error.	No of Comp. stars.	No. of obs.	Proper Motion.
α Tauri,	+0″.116	±0″.029	6	64	0″.202
α Aurigæ,	+0 .107	0 .047	2	16	0 .442
α Orionis,	−0 .009	0 .049	2	16	0 .022
α Canis Minoris,	+0 .266	0 .047	2	16	1 .257
β Geminorum,	+0 .068	0 .047	2	16	0 .628
α Leonis,	+0 .093	0 .048	4	15	0 .255
α Boötis,	+0 .018	0 .022	10	89	2 .287
α Lyræ,	+0 .034	0 .045	2	30	0 .344
α Aquilæ,	+0 .199	0 .047	4	16	0 .647
α Cygni,	−0 .042	0 .047	4	16	0 .010

The probable errors here given include an estimation of the probable *systematic* error of the measures, derived from the agreement of the independent results from the several pairs of comparison stars where more than one such has been employed. They are therefore considerably larger than those generally assigned to such results, which, as a rule, only take into account the mere *casual* error of observation.

It will be seen on inspection of the table that of the ten stars six may be said to give indications of a measurable parallax, but in only two cases are the values in any degree

* Report of W. L. Elkin, Astronomer in charge of the Heliometer, at the Observatory of Yale University, New Haven, Ct.

remarkable. These are those for α Canis Minoris and α Aquilæ, and it is worth while to note that they confirm closely results of former investigators, namely those of Auwers and Wagner on Procyon, which gave +0″.240 ±0″.029 and +0″.299 ±0″.038 respectively, and that of W. Struve at Dorpat on Altair, which gave +0″.181 ±0″.094. On the other hand my next two largest results, those for Aldebaran and Capella do not confirm the larger values found by O. Struve at Pulkowa, which were +0″.516 ±0″.057 and +0″.305 ±0″.043. In the case of the former star I am, however, in close agreement with Hall at Washington, who found +0″.102 ±0″.030, and there seems to be but little doubt that the Pulkowa value is largely in error. There have been no results of any importance derived hitherto for Pollux and Regulus, the remaining two of the six stars where the effect of parallax is at all sensible.

Of the four stars where the parallactic displacement has been inappreciable, Arcturus, with its large proper motion of over 2″, second only to that of α Centauri in all of the 200 brightest stars down to the fourth magnitude, is especially noteworthy. The minuteness of the parallax is beyond doubt, depending as it does on five pairs of comparison stars, all in reasonable agreement, and it cannot be considered as seriously at variance with results previously obtained by Peters and Johnson, +0″.127 ±0″.073 and +0″.138 ±0″.052 respectively, when their liability to systematic error is duly taken into account. For α Orionis and α Cygni, in view of their extremely small proper motions, the insensibility of their parallaxes is not surprising. The Yale result for α Lyræ, however, does not fall in well with those which have been hitherto deduced for this star. If we commence at the epoch of W. Struve and neglect the earlier attempts to find the absolute parallax, we have the following list of values:

W. Struve at Dorpat, 1837-40,	+0″.261	±0″.025
Peters at Pulkowa, 1842,	0 .103	0 .053
O. Struve at Pulkowa, 1851-53,	0 .147	0 .009
Johnson at Oxford, 1854-55,	0 .154	0 .046
Brunnow at Dublin, 1868-69,	0 .212	0 .010
Brunnow at Dublin, 1870,	0 .188	0 .033
Hall at Washington, 1880-81,	0 .134.	0 .0055

from which a parallax of about +0″.17 would seem well assured. The pair of comparison stars used here is very

symmetrical and so large a value would seem incompatible with Heliometer measures: I hope, however, to be able to trace the discordance to its source.

In planning this work the object in view was the determination of the average or mean parallax of the stars of the first magnitude, and in pursuance of this I may state that the mean of the 10 values above given is

$$+0''.085 \qquad \pm 0''.015,$$

to which should probably be added $+0''.004$ as the probable parallax of the comparison stars which are in the mean of about the eighth magnitude, giving

$$+0''.0890 \qquad \pm 0''.015$$

for the result sought for. I do not, however, in view of the wide range of distance implied by the values of the above table, feel at all certain that this result may be taken as a measure of the average distance of the stars in question, and at all events it must be considered only as provisional and partial until it can be combined with the results for the first magnitude stars of the Southern Hemisphere, now in course of determination by Dr. Gill. At the same time I might draw attention to its near coincidence with the values derived by Gyldén ($0''.084$) and Peters ($0''.102$)—without, however, wishing to lay too much stress on this agreement.

FORMATION OF SUNSPOTS.

JOHN R. HOOPER.

The following table is derived from a careful examination of 422 diagrams made at the eye-piece and extending from Jan. 1st, 1882, to Oct. 31st, 1885, thus embracing the time of greatest sunspot activity.

Large groups, evidently proceeding from the same centers of causation, have been considered as single spots and care was taken to avoid counting spots twice. No attempt is made to identify spots which may have made a second appearance, but the scrutiny is confined to the behavior of all spots as they presented themselves upon the disk of the sun.

Whatever the cause, or perhaps, wherefore the coincidence, the fact is shown, that a large majority of the sunspots

come into view from the farther side of the sun, fully formed. The few spots originating on the near side of the sun were mostly of inferior importance. A tendency to stop enlargement and even to lessen size, was also apparent while the spots continued on this side of the sun. The claim is not made that our earth can thus influence the place of origin, or modify developement and subsidence, of solar commotions; the table results from an attempt to answer a question of a fellow sunspot observer. "Why do all sunspots of any importance always come around the corner?"

A study of the records of the past thirty years, and preferably photographs, might yield some useful information.

The record of the present minimum is to be reduced later on, and an attempt will be made to study the next maximum from this standpoint very exhaustively.

This paper is put forth, hoping others who have kept drawings may make a similar examination.

TABLE.

	SPOTS.	
Originated on Disk, and increased	5	
" " " remained same	8	
" " " diminished	9	
		— 22
On the Disk after 4 to 6 days cloudy weather and increased	0	
On the Disk after 4 to 6 days, remained same	10	
" " " " " " " diminished	3	
		— 13
Came in on limb and increased	41	
" " " " " remained same	125	
" " " " " diminished	55	
		—221
Total		256

METROLOGY AT THE NORTHWESTERN UNIVERSITY.

The Northwestern University of Evanston, Ill., has recently organized a Beaureau of Metrology, etc., with Dr. M. D. Ewell as director. The instrumental equipment of this Bureau comprises, among other things, two dividing engines, by Professor W. A. Rogers, one small and non-automatic, and the other the very perfect machine upon which Professor Rogers has hitherto executed his superior rulings. This machine has two precision screws, one ½ meter long

with a pitch of $\frac{1}{20}$ inch, and the other about six inches long with a pitch of $\frac{1}{50}$ inch. Both these screws are fine specimens of workmanship and the smaller one is very nearly perfect. The large machine is entirely automatic when executing rulings finer than $\frac{1}{1000}$ inch. The Bureau also has two comparators both by Professor Rogers, one small and the other large and capable of comparing standards up to 114 centimeters in length. Both are constructed with adjustable stops, the standards to be compared being compared with the constant distance between the stops, from which their relation to each other is ascertained. The larger comparator has co-efficient of expansion, end-measure and ruling attachments and is practically a perfect instrument. Among the standards are a Sir Joseph Whitworth yard and its subdivisions, a yard and meter line-measure upon a steel surface by Clark, a ½ yard and ½ meter on aluminum bronze and other short standards, all ruled and investigated by Professor W. A. Rogers.

For thermometric standards there are among others four Kew Standards, two by Baudin, six by Geissler and two very perfect standards by H. J. Green of New York. The last standards by Green are exceptionally fine, the calibration of one being perfect the whole length of the scale, and the other having only one error and that so small as to be almost, if not quite, within the error of observation. With these are boiling-point and freezing-point apparatus and a water comparator devised by Dr. Ewell for the comparison of thermometers.

The work of the Bureau will consist principally in the preparation and investigation of standard micrometers and larger scales, and in the comparison of thermometers. Some little time longer will be occupied in the investigation of the long screw, as the systems of correction change every time the machine is dismounted, after which some special line of investigation will be adopted, which will be duly announced.

The Examination of the Eclipsed Moon is the title of a valuable paper recently read by George F. Burder before the Bristol Naturalists' Society May 3, 1888.

CURRENT INTERESTING CELESTIAL PHENOMENA.

THE PLANETS.

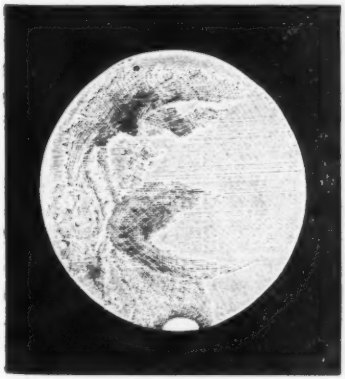
Mercury will be at greatest elongation west from the sun, 19°34′, Nov. 16, when it will rise an hour and three-quarters before the sun. The declination of the planet, however, is so far south that it will not reach a sufficient altitude to be well seen in northern latitudes. Mercury will be in conjunction with the moon, 3°34′ south, on Dec. 2 at 2:45 A. M. central time.

Venus is coming into better position for observation especially in the southern hemisphere. Her altitude will be pretty low for northern observers. She is "evening star," and will be easily recognized in the southwest between Jupiter and Mars, and brighter than either of them. It will be seen from the tables that Venus sets from two to three hours later than the sun during the month Nov. 15 to Dec. 15.

Mars continues in about the same position with reference to the sun, the change being slightly to the better for observation, but its distance from the earth has increased to about three times that of the planet's opposition in April, so that but little detail may be expected to be visible upon its surface. The October number of *L'Astronomie* contains four more drawings of Mars, made in May and June, 1888, by M. Perrotin with the 30-inch refractor at Nice, each showing some of the "canals," and especially one new one extending several hundred miles in a meridional direction, from the north polar *cap*, parallel to a previously known canal. M. Perrotin also speaks of the marked changes which he has noticed in the detail of Mars' surface during the long continued observations of a single night; affecting especially the dark spots of the surface. In the same number of *L'Astronomie* there are two attempted geological explanations of the canals: the one by Dr. Eug. Penard, of Geneva, that they are immense fissures, produced by the contraction of the planetary mass, through which the waters of the oceans flow; the other by "a Subscriber," whose name is not given, that the canals are wrinkles on the crust of the planet, or mountain ranges.

It may be of interest here to reproduce a drawing of the

planet Mars made by the writer (H. C. Wilson) in 1886 with the 11 inch equatorial of Cincinnati Observatory. The drawing was made at 12*h* 30*m* March 6, 1886, a night when the seeing was the most exquisite ever experienced during the six years spent at that observatory. The observer was not then at all familiar with the configuration of Mars' surface and drew what he could see without effort. At least three of Schiaparelli's canals are shown. The north polar ice cap was very white and sharply defined.



MARS. March 6, 1886, at 12*h* 30*m*, as seen with 11-in. refractor, power 450.

In copying the drawing the outline of the disk was constructed by mistake from data pertaining to Mercury instead of Mars. The mistake was not noticed until after the cut had been engraved. The disk should be almost circular as the drawing was made within one day of opposition.

Jupiter will come to conjunction with the sun on Dec. 8, and is now so near the latter (apparently) that no observations of value can be made.

Saturn is in good position at midnight now and in December may be observed after 10 P. M. He will be in quadrature with the sun November 11, and stationary in his apparent course among the stars November 30. It will be noticed from the tables that the motion during the whole month, November 15 to December 15, is less than a minute in right ascension and 10′ in declination. In Monthly Notices of the R. A. S. for June, 1888, Mr. T. G. Elger gives a resumé of his observations made with an 8½ inch silver-on-glass reflector by Calver during the first four months of the year. Several interesting points are noted, among which are, the varying color of the planet and rings, due probably to atmospheric causes; Encke's division frequently seen as a faint, delicate dark line; Cassini's division not perfectly black or well defined except at the inner edge; the outer edge being some-

times "fuzzy" and without any definite limit; irregularities in the brightness of different segments of the middle ring; a dark line traced part of the way round between the middle and inner rings; inner edge of inner or dusky ring irregular and sometimes deeply notched; marked change in the belts since 1887; distorted appearance of the shadow of the planet upon the rings. Speaking of the abnormal features noted Mr. Elger says: "It is perhaps noteworthy that those with sufficient optical means, who do *not* see them, are more or less desultory observers of the planet, while those just mentioned [Messrs. Trouvelot, Terby and others] examined it on every available opportunity. Continuous observation night after night doubtless tends to educate the eye, so that it soon becomes so familiar with the object scrutinized that delicate features, which are either only doubtfully glimpsed or not seen at all by the occasional gazer, are readily detected whenever definition permits.

"No telescope of the largest type has of late, so far as I know, been brought to bear upon the rings of Saturn. It is to be hoped that this will be done before they become too unfavorably placed for the detection of abnormal details."

Uranus may be seen in the morning. He will be found about 3° almost exactly north of Spica.

Neptune will be in opposition to the sun November 22, and is therefore in very favorable position for observation. It will be difficult to find this planet without an equatorial telescope provided with circles. It is about 5° south and as far east of the Pleiades.

MERCURY.

	R. A.	Decl.	Rises.	Transits.	Sets.
	h m	′	h m	h m	h m
Nov. 15	14 12.2	−10°47′	5 11 A. M.	10 31.4 A. M.	3 53 P. M.
25	14 58.3	−15 06	5 36 "	10 38.2 "	3 40 "
Dec. 5	15 57.9	−19 53	6 18 "	10 58.3 "	3 39 "
15	17 03.0	−23 22	7 00 "	11 23.8 "	3 47 "

VENUS.

Nov. 15	17 44.6	−24 59	9 48 A. M.	2 03.4 P. M.	6 19 P. M.
25	18 38.8	−25 01	10 03 "	2 17.9 "	6 33 "
Dec. 5	19 32.1	−23 49	10 10 "	2 31.8 "	6 53 "
15	20 23.7	−21 28	10 11 "	2 43.9 "	7 17 "

MARS.

Nov. 15	19 17.0	−23°46′	11 14 A. M.	3 35.6 P. M.	7 57 P. M.
25	19 49.9	−22 31	11 01 "	3 28.9 "	7 57 "
Dec. 5	20 21.9	−20 51	10 46 "	3 21.9 "	7 58 "
15	20 53.7	−18 47	10 29 "	3 14.4 "	8 00 "

JUPITER.

	R. A.	Decl.	Rises.	Transits.	Sets.
	h m		h m	h m	h m
Nov. 15	16 43.0	−21 48	8 30 A. M.	1 01.7 P. M.	5 33 P. M.
25	16 52.5	−22 06	8 02 "	0 31.8 "	5 02 "
Dec. 5	17 02.2	−22 22	7 38 "	0 02.2 "	4 30 "
15	17 12.0	−22 35	7 05 "	11 32.7 A. M.	4 00 "

SATURN.

Nov. 15	9 31.6	+15 38	10 40 P. M.	5 47.5 A. M.	12 55 P. M.
25	9 32.2	+15 37	10 02 "	5 08.9 "	12 16 "
Dec. 5	9 32.2	+15 39	9 22 P. M.	4 29.6 "	11 37 "
15	9 31.5	+15 45	8 42 "	3 49.6 "	10 57 "

URANUS.

Nov. 15	13 14.2	− 7 12	4 01 A. M.	9 36.2 A. M.	3 11 P. M.
25	13 16.0	− 7 23	3 23 "	8 57.0 "	2 31 "
Dec. 5	13 17.8	− 7 35	2 46 "	8 19.0 "	1 52 "
15	13 19.3	− 7 42	2 09 "	7 41.5 "	1 14 "

NEPTUNE.

Nov. 15	3 57.3	+18 42	4 53 P. M.	12 14.3 A. M.	7 36 A. M.
25	3 56.1	+18 38	4 13 "	11 33.8 P. M.	6 55 "
Dec. 5	3 55.0	+18 35	3 33 "	10 53.3 "	6 14 "
15	3 53.9	+18 32	2 52 "	10 12.9 "	5 34 "

THE SUN.

Nov. 10	15 05.4	−17 26	6 52 A. M.	11 44.1 A. M.	4 36 P. M.
15	15 25.9	−18 45	6 59 "	11 44.9 "	4 30 "
20	15 46.7	−19 56	7 06 "	11 46.0 "	4 26 "
25	16 07.8	−20 57	7 12 "	11 47.4 "	4 23 "
30	16 29.3	−21 49	7 18 "	11 49.2 "	4 21 "
Dec. 5	16 51.0	−22 30	7 23 "	11 51.2 "	4 19 "
10	17 13.0	−23 01	7 28 "	11 53.4 "	4 19 "
15	17 35.1	−23 20	7 32 "	11 55.8 "	4 19 "

Ephemeris of Variable Stars of the Algol Type.

[*Approximate Central Time of Minima; from Astronomical Journal, No. 182.*]

	d	h			d	h	
Nov.	10	9 P. M.	λ Tauri.	Nov.	27	8 P. M.	Y Cygni.
	11	1 A. M.	Algol.		29	6 P. M.	U Cephei.
	12	9 P. M.	Y Cygni.		30	8 P. M.	Y Cygni.
	13	10 P. M.	Algol.	Dec.	1	2 A. M.	Algol.
	14	6 P. M.	λ Tauri.		2	6 P. M.	R Canis Maj.
	14	7 P. M.	U Cephei.		3	8 P. M.	Y Cygni.
	15	5 P. M.	R Canis Maj.		3	9 P. M.	R Canis Maj.
	15	9 P. M.	Y Cygni.		3	11 P. M.	Algol.
	16	7 P. M.	Algol.		4	6 P. M.	U Cephei.
	16	8 P. M.	R Canis Maj.		5	12 A. M.	R Canis Maj.
	17	5 P. M.	S Cancri.		6	4 A. M.	R Canis Maj.
	17	11 P. M.	R Canis Maj.		6	4 P. M.	S Cancri.
	18	5 P. M.	λ Tauri.		6	8 P. M.	Algol.
	18	9 P. M.	Y Cygni.		6	8 P. M.	Y Cygni.
	19	2 A. M.	R Canis Maj.		9	5 P. M.	Algol.
	19	3 P. M.	Algol.		9	6 P. M	U Cephei.
	19	7 P. M.	U Cephei.		9	8 P. M.	Y Cygni.
	21	8 P. M.	Y Cygni.		10	5 P. M.	R Canis Maj.
	24	7 P. M.	U Cephei.		11	8 P. M.	R Canis Maj.
	24	7 P. M.	R Canis Maj.		12	8 P. M.	Y Cygni.
	24	8 P. M.	Y Cygni.		12	11 P. M.	R. Canis Maj.
	25	10 P. M.	R Canis Maj.		14	5 P. M.	U Cephei.
	27	1 A. M.	R Canis Maj.				

Occultations Visible at Washington.

Date.		Star's Name.	Magnitude.	IMMERSION. Wash. Mean T.	IMMERSION. Angle f'm N. P't.	EMERSION. Wash. Mean T.	EMERSION. Angle f'm N. P't.	Duration.
				h m	°	h m	°	h m
Nov.	7	ν^1 Sagittarii	5	5 37	124	6 33	324	0 56
	7	ν^2 Sagittarii	5	6 03	113	7 05	234	1 02
	9	20 Capricorni	6½	9 00	33	9 53	286	0 53
	18	δ^2 Tauri	5½	17 00	101	18 05	243	1 05
	23	35 Cancri	6½	12 57	82	14 20	290	1 22
	23	ε Cancri	6½	17 02	17	Star 0.9′ N. of moon's limb.		
	25	37 Leonis	5½	12 05	102	13 09	283	1 04
Dec.	9	ζ^2 Aquarii	4	8 20	329	Star 9.0′ N. of moon's limb.		
	9	ζ^3 Aquarii	4½	7 45	81	8 56	219	1 11
	10	30 Piscium	4½	3 50	130	4 21	173	0 31
	13	ξ^2 Ceti	4½	10 51	154	Star 6.1′ S. of moon's limb.		

Phases of the Moon.

		Central Time. d	h	m	
New Moon	Nov.	3	6	02	P. M.
First Quarter	"	10	10	16	A. M.
Full Moon	"	18	9	16	"
Last Quarter	"	26	11	20	"
New Moon	Dec.	3	4	6	"

Ephemeris of Comet c 1888 (*Brooks*). The following ephemeris of Comet *c* is from the *Astronomische Nachrichten*, No. 2860, elements by Dr. Krueger. The ephemeris was computed by J. Möller, for 12*h* Berlin mean time.

1888.	*a* h	m	s	*δ* °	′	log. *r*	log. Δ	L.
Nov. 2	16	56	26	−1	42.0			
4	17	0	33	2	23.2	0.2633	0.4034	0.10
6		4	36	3	2.7			
8		8	35	3	40.6	0.2753	0.4172	0.09
10		12	30	4	17.0			
12	17	16	21	−4	51.8	0.2870	0.4306	0.08

We are sorry not to be able to present an ephemeris of Barnard's comet, though it is so bright that any one knowing its locality will doubtless easily pick it up when the moon is out of the way. The ephemeris will be in hand a few days later, and will be sent to any observer in need of it.

Comet e, 1888 (Barnard), was seen by Mr. J. M. Parkhurst, Marengo, Ill., October 9, 10, 14. It was very faint.

Last Observation of Comets. It is especially requested that observations of any of the comets of this year, near the time of disappearance, be sent us that the records of all may be as complete as possible.

EDITORIAL NOTES.

The Old and New Astronomy. The readers of this important new book will be gratified to learn that its publishers, Messrs. Longmans, Green & Co., will carry out the original plan of its publication as heretofore announced. This is possible because Mr. Proctor had nearly completed the copy for the work before his sudden death.

Definitive Determination of Comet 1887 IV. Mr. Frank Muller, of the Leander McCormick Observatory, University of Virginia, has completed and published a Definitive Determination of Comet 1887 IV. This work was presented to the Faculty of the University of Virginia on applying for the degree of Doctor of Science.

Catalogue of Variable Stars by Chandler. Those interested in the study of variable stars will find S. C. Chandler's catalogue of variable stars (*Astronomical Journal*, No. 179–80) the latest and the most complete work of its kind anywhere in print so far as we know.

New Nebulæ, Catalogue No. 7, Warner Observatory. Dr. Swift has published in *A. N.*, No. 2859, Catalogue No. 7, containing 100 new nebulæ which have been found at Warner Observatory since the publication of Dr. Dreyer's New General Catalogue. In this catalogue he calls attention to the fact that an inspection of all the lists of new nebulæ will show an extraordinary number in Draco where formerly but few were known. Preceding October 13 Dr. Swift had discovered forty-three more new nebulæ, a large beginning for the eighth catalogue.

Comet e, 1888. There seems to be a little discrepancy in *Science* Circular, No. 82, as to the dates of Mr. Barnard's discovery, and the independent discovery by Mr. Brooks, of Geneva, N. Y. Mr. Barnard found the comet Monday morning, Sept. 3, and Mr. Brooks on Tuesday morning, Sept. 4, civil reckoning. The astronomical dates would, of course, be respectively Sept. 2 and 3. The two discoveries were separated by one day and not two.

Bessel's Log. B for Great Elevations.

Bar. inches.	Log. B.	Diff.	Bar. inches.	Log. B.	Diff.
20.0	—0.17021		23.8	0.09467	
.1	0.16805	+216	.9	0.09285	+182
.2	0.16589	+216	24.0	—0.09103	+182
.3	0.16375	+214	.1	0.08923	+180
.4	0.16161	+214	.2	0.08743	+180
.5	0.15949	+212	.3	0.08564	+179
.6	0.15738	+211	.4	0.08385	+179
.7	0.15527	+211	.5	0.08208	+177
.8	0.15318	+209	.6	0.08031	+177
.9	0.15110	+208	.7	0.07855	+176
21.0	—0.14902	+208	.8	0.07679	+176
.1	0.14696	+206	.9	0.07504	+175
.2	0.14490	+206	25.0	—0.07330	+174
.3	0.14286	+204	.1	0.07157	+173
.4	0.14083	+203	.2	0.06984	+173
.5	0.13880	+203	.3	0.06812	+172
.6	0.13679	+201	.4	0 06641	+171
.7	0.13478	+201	.5	0.06470	+171
.8	0.13279	+199	.6	0.06300	+170
.9	0.13080	+199	.7	0.06131	+169
22.0	—0.12882	+198	.8	0.05962	+169
.1	0.12685	+197	.9	0.05794	+168
.2	0.12489	+196	26.0	—0.05627	+167
.3	0.12294	+195	.1	0.05460	+167
.4	0.12100	+194	.2	0.05294	+166
.5	0.11906	+194	.3	0.05129	+165
.6	0.11714	+192	.4	0.04964	+165
.7	0.11522	+192	.5	0.04800	+164
.8	0.11331	+191	.6	0.04636	+164
.9	0.11141	+190	.7	0.04473	+163
23.0	—0.10952	+189	.8	0.04311	+162
.1	0.10763	+189	.9	0 04149	+162
.2	0.10576	+187	27.0	—0.03988	+161
.3	0.10389	+187	.1	0.03827	+161
.4	0.10203	+186	.2	0.03667	+160
.5	0.10018	+185	.3	0.03508	+159
.6	0.09833	+185	.4	0.03349	+159
.7	0.09650	+183			

Some years ago I computed Bessel's log. B from barometer = 27.4 inches down to barometer = 15.0 inches, and as I have never seen any similar table, it has occurred to me that astronomers who may have occasion to make astronomical observations at great elevations might find them of some value, and I therefore venture to send such a table of log. B between the limits of 20.0 inches and 27.4 inches to THE SIDEREAL MESSENGER. Professor Harkness is of opinion that for altitudes above 4,000 feet the value of log. B may be too large. (See *Astronomical Journal*, No. 182.)

Washington, Oct. 13, 1888. H. P. TUTTLE.

Heliometer Work at Yale Observatory. Dr. W. L. Elkin, in his last report, gives a glance at the work going on in the

observatory by the aid of his fine heliometer. He says it "is now being employed in a triangulation of the stars in the vicinity of the North Pole. Early in the year Professor Pickering, of Harvard, applied to us to determine the relative places of a few stars to serve as fundamentals for a catalogue of stars within one degree of the Pole, by photographic methods. I have concluded to enlarge the plan originally laid out for this purpose, and am now observing 24 stars within 100′ of the Pole, nearly all that are measurable with the heliometer in the area. The work is well under way, but as a considerable portion of the months of October, November and December are to be devoted to the joint observation with Dr. Gill of the extremely favorable opposition of Iris for a determination of the solar parallax it may not be completed before next year.

Mr. Hall has been steadily occupied with the reduction of his measures of Titan, which is now approaching completion. In this connection he has made an extensive series of measures on the division errors of the parts of the scale in use therefor. He has also taken up for investigation of their parallaxes the stars 6 B Cygni and 18115-22 Lalande, both of which present special interest.

The series of measures of the sun's diameter has been continued, a special research having been undertaken on the influence of different apertures upon the same, and upon the scale value. We have also made some measures of the diameter of Mars at its late opposition and of various double stars."

The Horizon at Lick Observatory. The dip of the horizon at Lick Observatory, Mt. Hamilton, California, as far as it is merely geometrical, can easily be computed from the altitude of the Observatory, which is 4,209 feet above sea level. The distance of the sea horizon (which is in view) is eighty-seven miles. The actual horizon is bounded by mountains of various heights all around except on the west in a few places. It would seem then the dip of the horizon to the west ought to be approximately 62′. It is still an interesting query to ascertain what the effect of refraction is at low altitudes at Mt. Hamilton. By kindness of Professor Holden we have the exact distances given above.

New Meridian Circle for Cincinnati Observatory. We have received a photograph of the new meridian circle just completed by Messrs. Fauth & Co., Washington, D. C., for the Cincinnati Observatory. In appearance the instrument is a beautiful one, and we have no doubt but that it is as good as it looks. At our request Messrs. Fauth & Co., are to furnish us a full page cut of this new instrument for the next MESSENGER, and Professor Porter, Director of the Cincinnati Observatory, has already prepared a description of it for publication. This is the largest and the finest instrument we believe that Messrs. Fauth & Co. have made up to this time. Its circles were divided on their large, new dividing engine, which is, we suppose, the best machine of its kind in this country, if not equal to the best in the world. A detailed cut of it was given in this journal not long ago.

Professor C. Piazzi Smyth, late Astronomer Royal and Professor of Practical Astronomy in the University of Edinburgh, favors us with a report of the Observatory, bearing date August 25, 1888. It is matter of very great regret that so able an astronomer as Professor Smyth should find it necessary to resign his place. His account of the causes leading to it will provoke surprise and shame in the minds of all lovers of astronomy the world over. When will the time come that government officials charged with the guardianship of the useful sciences, will either know enough, or care enough about their welfare not to desert them, say nothing about actual starvation. We indulge the hope that Professor Smyth will soon be recalled to his old position, with the Observatory refitted in such a way as it should be for a government astronomical observatory to be used in modern times.

Leander McCormick Observatory. The last report of Professor Stone, Director of the Leander McCormick Observatory, University of Virginia, shows for the year ending June 1, 1888, that 154 southern nebulæ have been observed at least twice, and 96 others once; that the motion of Hyperion, the seventh satellite of Saturn is nearly commensurate with that of Titan, the sixth satellite, whose mass is much larger than that of either of the other

satellites of Saturn. These satellites approach very near to each other at conjunction; as a result the ordinary methods for determining the motion of Hyperion are inapplicable. From a discussion of the problem Professor Stone finds that the mass of Titan is much larger than had hitherto been supposed, and his result has been confirmed by Mr. G. W. Hill who used an entirely different method.

Bibliography of Astronomy for 1887. William C. Winlock, assistant astronomer at the United States Naval Observatory, has compiled a subject-index of astronomy for the year 1887, which forms an interesting general review of the progress of astronomy during that year. The sources of information have been scientific journals, the transactions of societies and more elaborate publications that have come to the compiler's notice. This is 664 of the Smithsonian Miscellaneous Collections, and the pamphlet contains 63 pages and 364 titles arranged in alphabetical order, the titles being printed neatly in heavy faced type.

Professor Comstock's Article of last month on "The Value of a Revolution of a Micrometer Screw," has one error in the formula on page 345, which was discovered by him too late to correct in the copy. The equation

$$\Delta\delta = \Delta x + \tfrac{1}{2}\Delta x\,(\sin \Delta y \tan \delta)^2 \text{ should read}$$
$$\Delta\delta = \Delta x + \tfrac{1}{8}\Delta x\,(\sin \Delta y \tan \delta)^2.$$

Astronomical Photography. The following circular will interest many of our readers, and therefore we print it in full:

In accordance with the wish expressed by the Astro-photographic Congress, held at Paris last year, we are now occupied with the constitution of a Committee to study the best methods of working and to collect results obtained in celestial photography, other than the photographic chart of the heavens (which is in the hands of the Committee of the Congress).

If you wish to take part in this work, we should be glad if you would send to either of us your adhesion.

Next year, when scientific congresses will be held in Paris, we intend to call together those who have thus expressed their adhesion in order to constitute a Committee, and examine the questions that we shall have to consider. We would further ask you to let us know if you would be disposed to take a part in this meeting to be held in Paris at a time to be hereafter notified.

J. JANSSEN,

(President de l'Academie des Sciences; Directeur de l'Observatoire d'Astronomie Physique de Paris), Meudon, (Seine et Oise), Paris.

A. A. COMMON, F. R. S.,

Eaton Rise, Ealing, London.

1888, September 15th.

Question sixth of the October number asks for a table of the most accurately measured distances of the stars.

Guillemin in his "Heavens," page 292, gives a table of the distances of eight stars expressed in astronomical units:

	Radii of earth's orbit.		Radii of earth's orbit.
α Centauri	211,330	ε Ursa Majoris	1,500,800
61 Cygni	550,920	Arcturus	1,622,800
Vega	1,330,700	Polaris	3,078,600
Sirius	1,375,000	Capella	4,484,000

The astronomical units may be converted into miles by multiplying by 92,500,000. I have made the multiplication by logarithms.

	Miles.		Miles.
α Centauri	19,548,025,000,000	ε Ursæ Maj	143,449,000,000,000
61 Cygni	50,960,100,000,000	Arcturus	150,109,000,000,000
Vega	123,089,750,000,000	Polaris	284,760,500,000,000
Sirius	127,187,500,000,000	Capella	404,770,000,000,000

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Queries. 8. There is an object in approximate R. A. 19*h* 25*m* and N. Decl. 9°5 that has the appearance of a comet in my 8½-inch reflector. There are two stars in same field, which form a right angle with the unknown object nearly. The stars are 14 or 15 magnitude. W. K.

In Dr. Dreyer's new general catalogue of nebulæ and star clusters there are two objects answering to the above position roughly; a planetary nebula, and more closely a faint star cluster marked *c*B, S, *i*R, *rrr*, meaning "considerably bright, small, irregularly round, well resolved, clearly consisting of stars." We have not had opportunity to verify

the object at the telescope, but think that the last object was the one seen. Our querist has probably mistaken the magnitude of the stars near, as 14th magnitude stars of the ordinary scale would be barely visible in a 10-inch glass.

9. Why do astronomers in their tables of elements of orbits of comets give the perihelion distance, q, by its logarithm, and the longitude of perihelion, longitude of node, and inclination by their natural numbers? A. B. C.

This is all very natural. Computers use formulæ that are made up chiefly of symbols like these referred to. Mathematicians are so familiar with all such terms that they incline to use them from choice, doubtless to the inconvenience of the popular reader who may have interest in such work. One familiar with the use of logarithms will not consult his tables once in ten times to know the natural number represented. He reads that approximately from the logarithm. We have known of one computer who rarely ever went to his tables for a four-place logarithm. He carried the tables in his mind to that extent. The reason that longitude of perihelion, longitude of node and inclination are given in natural numbers (so-called), is because logarithms of arcs or angles are scarcely ever used in computations of this kind. Work is done by logarithms on trigonometric functions, and tables give the angles that belong to the functions found.

For the benefit of readers troubled by these symbols we will gladly give the plainer statement of the elements of comets in the future.

10. On page 354 it is said that the table (elements) shows that the comet is receding from the earth. How does it show that? A. B. C.

That statement was made when we intended to print an ephemeris. Later that was thought undesirable, but inadvertantly the last line, which did not belong to the elements, but did apply to the ephemeris, was not withdrawn as it should have been.

Doubtless some of our readers would like to share in answering queries sent to the MESSENGER. Here are a few that came just as we are ready to go to press, and we can only give room for them without answer, which will appear later:

11. Why do almanacs in giving the times of the moon's rising say "morning", instead of giving the time, as, for instance, on Oct. 13 of the present year? Between the preceding two and the following two days there is a difference betwen her risings of about an hour, whereas between the 12th and 14th there is but about an hour difference. She must certainly rise at the same time on the 13th and why not give the time instead of saying "morn?" A. B. C.

12. Why do nearly all text-books on astronomy fail to state that there is such a thing as precession in declination? All devote a chapter to precession in right ascension, but scarcely an instance can be found where the former is dealt with, or even hinted at. A. B. C.

13. At certain times of the year, especially in November, why is there a difference of half an hour between the lengths of the forenoons and afternoons? A. B. C.

14. How is the oft repeated statement made by astronomers explained that the sun attracts a comet and at the same time repels it to form its tail? How can the sun simultaneously attract and repel? A. B. C.

15. If, at the equator, a ball be fired from an accurately zenith pointing rifle, to a height of fifty miles, will it at its descent strike the earth east or west of the gun? How would it fall if the experiment were tried at St. Petersburg? A. B. C.

16 Is the orbit of the earth, so called, the path of the center of the earth's mass? P. M.

17. What is a dialytic telescope? E. W. A.

Next time we shall speak of the progress of Professor H. A. Howe in planning and building the new observatory for the University of Denver.

We have received a lengthy and interesting paper on the velocity of sound. It claims to prove that physicists are wrong in accounting for the difference between theoretical and observed velocities of sound waves or pulsations on the ground of the agency of heat. The theoretical and the observed volumes of these pulses should agree, and do agree when rightly computed, without considering the development of heat at all.

American Telescopes. Professor David P. Todd, Amherst College, prepared the paper on American Telescopes and

telescopic work done in the United States which is found in the appendix to vol. xxiii, Encyclopedia Britannica, American reprint. This article speaks of the telescope in use as early as 1830, and the one projected and built in 1838 by E. P. Mason and H. L. Smith (now Professor Smith of Hobart College); of the beginning of Celestial photography, in 1850, by Professor Bond of Cambridge who tried Vega and the double star Castor, and the work of Bartlett of West Point in 1854 and Campbell of New York; of the results of L. M. Rutherford of New York with an 11¼-inch objective figured by himself; of Dr. Henry Draper's success in the same time by the aid of a still larger telescope which is still in use in the researches of the Henry Draper memorial at Harvard College Observatory; of the marked success of the Professors Pickering at the last named Observatory, and, in general, the large promise that belongs to this new branch of astronomy. Considerable space is rightly given in this review of current astronomical work in America, to the makers of astronomical instruments, in which the following names appear: Spencer of Canastota, N. Y., Clacy of Boston, Lyman of Lennox, Mass., Professor Hastings of Yale Scientific School, Clark Brothers of Cambridgeport, Mass., Young of Philadelphia, Messrs. Fauth & Co., Washington, and Brashear of Allegheny City, Pa. This interesting paper closes with a brief description of the discoveries that have been made by American astronomers, which will signify the kind of work done, as well as the progress of the science on this side of the Atlantic.

A planet of the 13th magnitude or fainter was discovered by Palisa Oct. 25.2486, Greenwich mean time, in R. A. $0^h\ 53^m\ 36.4^s$; Decl. $+2°\ 54'\ 58''$.

Readers of mathematics will find food for thought in Mr. Corrigan's article, the leader of this issue. In our next this paper will be concluded, showing some surprising results.

Dr. B. A. Gould, editor of the *Astronomical Journal*, Cambridge, Mass., who has been abroad for several months, is expected to return about the first of November. S. C. Chandler has edited the *Journal* in Dr. Gould's absence.

Important Papers from Harvard College Observatory have been received bearing the following titles: Total Eclipse of the Moon, Jan. 28, 1888; Photometric Observations of Asteroids, by Henry M. Parkhurst; and Total Eclipse of the Sun, Aug. 29, 1886, by William H. Pickering. These papers deserve more than a mere mention by title. We would give full notice of them now but for lack of space. Some parts of them show excellent results in photography. Abstracts may be presented later.

BOOK NOTICES.

Planetary and Stellar Studies, or Short Papers on the Planets, Stars and Nebulæ, by John Ellard Gore, F. R. A. S., etc. London: Messrs. Roper & Drowley, 29 Ludgate Hill, E. C., 1888, pp. 264. Price 7*s* 6*d*.

For many years past Mr. Gore's writings on astronomical themes have been favorably known to those acquainted with the science, and this book is largely a reprint of papers previously published by him. Some of them have been re-written and brought down to date, and those on the planet Mercury, the Minor Planets, Uranus and Neptune, and the Distances of the Fixed Stars are entirely new. As a whole the book is an interesting brief review of Planetary Astronomy and Sidereal Astronomy. The characteristics of each of the planets are noticed and a statement of authority made, giving, as far as we know, late and reliable information. While enough is said about the supposed satellite of Venus, no mention is made of the supposed Vulcan or other intra-Mercurial planets. The six lithographic plates of Mars' surface, as observed in 1877, when at last nearest approach to the earth, give considerable surface detail, but show scarcely anything that looks like the parallel canals of Schiaparelli. This is not surprising, because, so far, the best American telescopes have not done much better. Pertaining to the stars are interesting articles on the double stars, variable stars, the distances of the fixed stars, the Milky Way, the Great Pyramid and the precession of the equinoxes, new stars, the masses and distances of the binary stars, the absolute dimensions of a star cluster, stellar photography, the zodiacal light and the infinity of space. The publishers have done their part of the work handsomely.

College Algebra, for the Use of the Academies, Colleges and Scientific Schools. With numerous examples.

Academic Algebra, for the Use of Common and High Schools and Academies. With numerous examples. Both by Edward A. Bowser, L.L. D., Professor of Mathematics and Engineering in Rutgers College. New York: D. Van Nostrand, publisher, 23 Murray and 27 Warren streets, 1888. College Algebra, pp. 540. Academic Algebra, pp. 352.

The College Algebra is a book complete in itself, as it starts with the beginning of algebra, using the first eighteen pages for definitions and the enunciation of first principles. The next one hundred and forty pages are devoted to the fun-

damental operations, factoring, divisors, multiples and fractions, with abundant examples for practice under each theme. To the equation of one and more unknown quantities are given about fifty pages, the methods of elimination being only the usual three.

After involution and evolution come the study of the theory of exponents and the radical quantity, including the binomial surd. The examples under these topics are well chosen and considerable in number.

Chapter XVIII. gives a new and convenient name to the proofs used in establishing certain propositions. It is called Mathematical Induction. The discussion of the imaginary quantity is considered next to the intermediate equation. The geometric meaning of the imaginary unit is helpful. The book closes with a short chapter on the theory of equations and Cardan's solution of the cubic equation. We are a little disappointed not to see the subject of infinitesimal analysis touched upon at all in this book, which is certainly very thorough in its treatment of all themes presented. The elements of this important branch ought to be in every college algebra, if necessary at the expense of several less useful topics ordinarily given.

The Academic Algebra is a book of 352 pages arranged on the same general plan as that already given. The subjects of quadratics, rates, proportion, progression and the binomial theorem are the last and most difficult ones given in this lower book.

We are sure that the teacher with beginning classes will find this a model book for the class-room. Mr. Van Nostrand's publishing house knows how to make a mathematical text-book that will afford constant pleasure in its use so far as the mechanical part of the work is concerned.

Our Celestial Home, An Astronomer's View of Heaven. J. G. Porter, A.M., Director of the Cincinnati Observatory. New York: Messrs. Anson, D. F. Randolph & Company, 38 West Twenty-third street; pp. 116.

This little book contains six articles titled as follows: Heaven a material locality, Heaven a part of the Universe, Habitablity of the celestial worlds, Stability of the Universe as to motion, Stability of the Universe as to force, Conclusion.

The author was led to this writing from the often expressed views that "the material universe is inevitably destined to decay and death, and therefore not fitted for an eternal dwelling place of the redeemed." Suppose that man were permitted to live on, here, in some form, the earth is gradually losing its energy of rotation on its axis, as well as that of revolution around the sun; the sun is losing his energy; the planets are growing old like the moon; the solar system must decay in time, and what happens to our system doubtless belongs alike to all stars, for our sun is but an inferior one of the great starry hosts of heaven, so that if these all are finite, they are doomed to utter dissolution. Although there is sublimity and grandeur in this visible universe of ours, its garment is not an immortal one. "We must look elsewhere if we would be clothed with immortality as with a garment." Eternal life is not merely existence prolonged forever; nor has Professor Drummond probably all in mind that pertains to it, when he says, "it is to know God, to have communion with Him." Evidently there is a higher range of human being not at all dependent on our present material environment. The author gives an astronomer's view of this, one who has thought and read carefully, and in happily chosen phrase brings to bear on it from astronomical science latest facts as he thinks they may be interpreted reasonably in the light of the Bible. We most heartily commend the noble spirit of this little book, in view of the common attitude of scientists at the present time, of professing to know little of, and to care less about, the relations of God to his glorious works, than almost anything else.

Books Received.

Wentworth's College Algebra, Messrs. Ginn & Co., publishers.

Bowser's Analytic Mechanic's; Bowser's Analytic Geometry; Bowser's Hydro-mechanics; all published by D. Van Nostrand.

Numbers Symbolized in Elementary Algebra, Messrs. D. Appleton & Co., publishers.

Goodsoe's Manual of Mechanics; Elementary Lessons in Mechanics; Elementary Lessons in Mechanics, second stage; all published by Messrs. Longman's, Green & Co.

Poetry and Prose by T. and T. H. Higginson.

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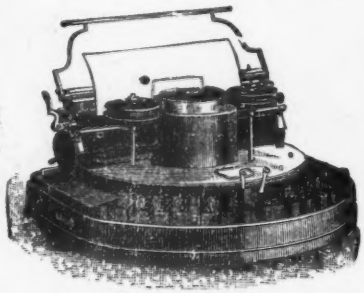

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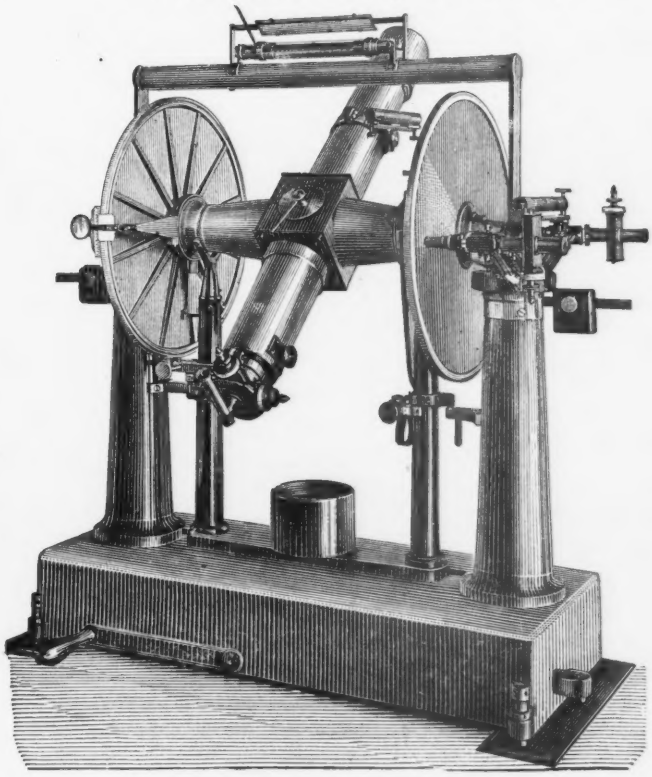

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